

**ODOR CONTROLLING ARTICLE INCLUDING A VISUAL INDICATING DEVICE  
FOR MONITORING ODOR ABSORPTION**

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**Background of the Invention**

The present invention generally relates to a visual indicating device for use in articles that control and absorb odors, and in particular, odors such as foot odor, urine odor, feces odor, garbage odor, tobacco odor and raw meat odor. The invention also relates to an odor absorbent article including such an indicating device.

Several products have been developed for odor control, most of which are based on odor masking, odor absorption or the degradation of odor forming compounds. In products where the odor is controlled through odor absorption, the user generally has no idea as to whether the odor absorbing article is working or not, other than by the slow removal of the offending odor. Thus, when the odor absorbing product has become saturated and needs to be replaced, the user would only become aware of this when the product stops absorbing the odor and the offending odor becomes noticeable. It would therefore be advantageous for the user to be made aware of the fact that the article was saturated and needed replacing prior to this situation arising.

In some situations it would also be advantageous if the user could be made aware that a odor is present, even though it was being absorbed and was not noticeable, so that the user could take steps to remove the cause of the odor, or could feel more at ease that the product was working efficiently.

US Patent No. 5,733,272 to Brunner *et al.* teaches the use of a fragrance or perfume to indicate that an odor is being removed. This fragrance is moisture-activated, and the scent is released in small bursts when wetted. US Patent No. 6,369,290 to Glaug *et al.* and PCT International Publication No. WO 98/26808 to Trinh also disclose the release of a fragrance to indicate that an odor is being removed.

However, the use of a fragrance is not always desirable, as not all users will find a fragrance to be pleasant, and there may be situations where the user would prefer the indicator to be a discreet type of indicator, rather than the release of a fragrance which could be detected by others. Such a system also does not indicate to the user when the odor absorbing product is saturated and needs to be replaced.

EP Patent No. 1 157 672 to Carlucci *et al.* discloses a liquid and odor absorbent structure for inanimate places such as refrigerators. The patent mentions that the structure may be provided with an indicator to indicate the end of the life time of the

structure, but goes no further than this in regard to the indicator, except to mention that the indicator would be a conventional indicating means known to those skilled in the art.

PCT International Publication No. WO 00/76558 to Persson describes the use of a visual indicator to indicate the activity of an active ingredient in an absorbing article. The visual indicator changes color in response to a change in the active additive in the absorbing article. This change in the activity of the active additive could be as a result of a number of reasons, for example a change in the environmental conditions.

The inventors are not aware of any existing visual indicating system which is suitable for use on an odor absorbent product and which changes color in direct response to an odor.

### **Summary of the Invention**

The invention provides an article for controlling a odor, the article comprising an odor absorbing agent and at least one visual indicating agent that changes color in response to the odor. Depending on the concentration of the indicating agent, the color change will be observed when the odor is present, when the odor is being absorbed or when the odor absorbing article is saturated and needs to be replaced.

As used herein the terms "odorous compound", "odor" and "odor" refer to any molecule or compound detectable to the olfactory system. Odorous compounds can exist as gaseous compounds and can also be present in other media such as liquid.

As used herein the term "odor absorbing agent" refers to a substance, compound, chemical, mixture or absorbent (such as activated carbon, clay, zeolites, coated or modified nanoparticle silica or alumina and molecular sieves) useful in controlling odors.

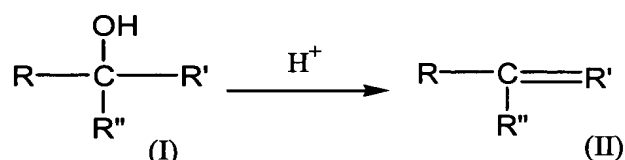
As used herein the term "visual indicating agent" refers to a substance, a composition or a material that gives a visual indication when a odor is present in a sufficient concentration.

The visual indicating agent is typically color-sensitive to at least one odors selected from the group comprising body odor, foot odor, garbage odor, urinary odor, feces odor, tobacco odor, raw meat odor, other common household odors such as bathroom, pet and cooking odors, mercaptans (or thiols), amines, ammonia, sulfur, sulfides, hydrogen sulphide, sulfur degradation products, aliphatic acids, isovaleric acid, butyric acid, and acetic acid.

Suitable visual indicating agents are selected from neutral red, 3-nitrophenol, brilliant yellow, chlorophenol red, Rose Bengal dye, D&C red 28 dye, 4,4'-bis(dimethylamino)-benzhydrol (BDMB or Michler's hydrol (MH)), methyl red, methyl violet,

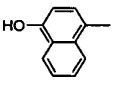
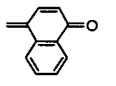
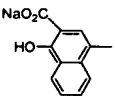
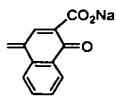
methyl orange, bromocresol mauve, Acid Blue 80, blue dye Calcocid Blue 2G, ethyl red, bromophenol blue, bromocresol green, crystal violet, cresol red, thymol blue, erythrosine B, 2,4-dinitrophenol, Eriochrome™ Black T, alizarin, bromothymol blue, phenol red, m-nitrophenol, o-cresolphthalein, thymolphthalein, alizarin Yellow Reller, cobalt salts and complexes, copper salts and complexes, copper phenanthroline complexes and iron salts and complexes.

Additional indicating agents are those represented by the following general formula (I) or (II):



where R, R' and R'' are as shown in Table 1:

**Table 1: Indicating agents having the general formula (I) or (II)**

Indicating Agent	R	R'	R''	Indicating Agent for
Michler's Hydrol (MH)	H	$(\text{CH}_3)_2\text{NC}_6\text{H}_5-$	$(\text{CH}_3)_2\text{NC}_6\text{H}_5-$	Thiols, Mercaptans, Ammonia, Amines, Diamines and Polyamines
Pararosaniline Base (PAB)	$(\text{NH}_2)\text{C}_6\text{H}_5-$	$(\text{NH}_2)\text{C}_6\text{H}_5-$	$(\text{NH}_2)\text{C}_6\text{H}_5-$	Ammonia, Amines, Diamines and Polyamines
Alpha-naphtholbenzene (ANB)	$\text{C}_6\text{H}_5-$			Ammonia, Amines, Diamines and Polyamines
Naphthochrome Green (NCG)	$\text{C}_6\text{H}_5-$			Ammonia, Amines, Diamines and Polyamines

The odor absorbing agent is typically activated charcoal, sodium bicarbonate, clay, zeolites, silicates, starches, ion exchange resins, cyclodextrins, molecular sieves or high surface area materials such as nanoparticles (see, for example, EP-A-348 978, EP-A-510619, WO 91/12029, WO 91/11977, WO 89/02698 and WO 91/12030).

In some instances, the visual indicating agent and odor absorbing agent may be the same agent. For example, BDMB may be used as both the odor absorbing agent and the visual indicating agent for sulfur, amine and ammonia odors.

Suitable odor absorbing articles to which the visual indicating agent may be applied include without limitation disposable diapers, training pants, undergarment pads, sanitary napkins, tampons, panty shields, incontinence pads, absorbent underpants, baby wipes, absorbent tissues, medical garments, bandages, absorbent drapes, medical wipes, face masks, air filtration media, air freshener products, disposable odor absorbing sheets for shoes, gym bags, lockers or garbage areas and so forth.

The visual indicating agent is applied to the article on a strip or patch attached to or printed on the odor absorbing article, and may be applied in a pattern such as a plurality of zones, dots, stripes, a circular shape or text that appears, fades or changes color when the visual indicating agent changes color. The patch or strip can be applied as a coating on any fabric or film layer, such as the breathable film of an outer cover of a disposable diaper, on the outer cover of an air freshening product or on a sheet for absorbing foot odor.

The visual indicating agent may be applied to the article in solution and allowed to dry so that a dried residue remains on the article. As used herein, the term "solution" refers to the indicating agent in a liquid such as water, an aqueous solution, alcohol, toluene and the like.

The device may include a single zone with a concentration of the indicating agent such that the indicating agent and hence the zone will change color to indicate that an odor absorbing device has reached saturation point and should be replaced.

However, as the concentration of the indicating agent and the amount of odor are the major factors determining the time in which the indicating agent takes to change color, the use of zones having different concentrations of the indicating agent allows a graduated scale to be produced that would indicate to the user that the odor absorbing article to which the strip or patch was applied was working and how much of the odor absorbing capacity was left (or conversely, how much of the absorbing article is used up). The final color or lack of color indicates when the absorbing article is saturated and needs to be replaced. The scale may be in the form of a linear scale, a circular scale, a collection of dots, text and so forth.

### **Description of the Figures**

Figure 1 shows a standard curve for the detection of furfuryl mercaptan by 4,4'-bis(dimethylamino)-benzhydrol (BDMB);

Figure 2 shows a standard curve for the detection of ammonia by BDMB;

Figure 3 shows a standard curve for the detection of urea by BDMB;

Figures 4(a) and 4(b) show two possible designs for a strip or patch forming the indicator device of the invention; and

Figure 5 shows a disposable diaper with an indicating device according to one embodiment of the invention.

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### **Detailed Description of the Invention**

There is currently no suitable system of visually indicating to a user when an odor absorption device has detected an odor and/or when the odor absorption device is saturated and needs to be replaced.

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It would be advantageous to a user of odor absorption articles, and in particular urine odor, feces odor, body odor, foot odor and other common household odors, if the odor absorption article included an indicator for visually indicating when an odor is present and/or when the article has reached a saturation point and needs to be replaced.

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Thus, the invention provides a visual indicating device for visually indicating when an odor absorbing article is saturated.

The major odorous components of common household odors, such as cat odor, dog odor, garbage odor, body odor, foot odor, food odor, urine odor, feces odor, and tobacco odor are amines, sulfur compounds, carboxylic acids and aldehydes.

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For example, the generation of odor from urine is mostly based on chemical and biological degradation of urine components, and amines, ammonia and sulfur degradation products (methyl mercaptan and hydrogen sulfide) are the major odor sources in urine. They can also be found in feces odor and body odor. Additionally, enzymes such as urease can convert urea, a major component in urine, to ammonia and thereby increase the generation of odors in urine. Aliphatic acids such as valeric, isovaleric, butyric and acetic acids are commonly found to be the major odor components in body odors, foot odor, tobacco smoke, raw meat, garbage (kitchen) odor, cat odor and the musty smell of basements and cellars.

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Table 2 shows the concentration of the chemical components of common household odors along with their human threshold values (concentration that can be detected by the human nose).

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**Table 2: Concentration of the chemical components of common household odors along with their human threshold values**

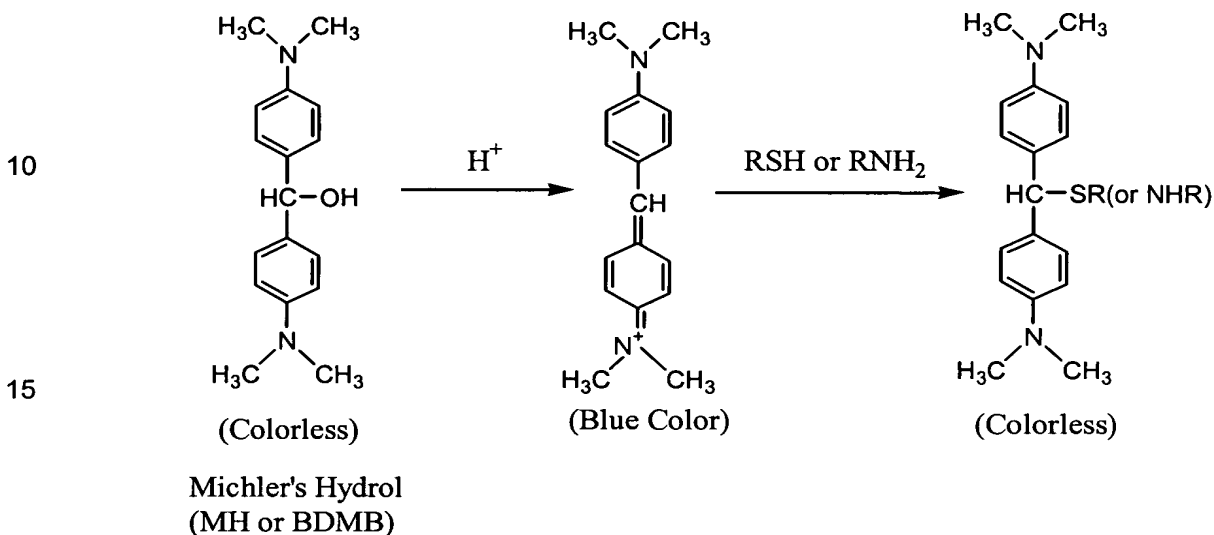
Odor	Major Chemical Components	Concentration (ppb)	Human Threshold (ppb)
Dog odor	Ammonia	5900	1500
	Trimethylamine	1500	0.03
	Methyl mercaptan	0.5	0.07
Cat odor	n-Butyric acid	0.3	0.19
	Ammonia	1980	1500
	Trimethylamine	0.3	0.03
Garbage odor	Methyl mercaptan	56	0.07
	n-Butyric acid	166	0.19
	n-Valeric acid	52	0.04
Sock odor (foot)	iso-Valeric acid	1.36	0.08
	n-Valeric acid	0.1	0.04
	Hydrogen sulfide	0.7	0.41
Cooking odor – Fish	Acetaldehyde	1740	1.50
	Dimethyl sulfide	41	3.0
	Hydrogen sulfide	11	0.41
Cooking odor – Shrimp	Acetaldehyde	15	1.5
	trimethylamine	96	0.03
	Hydrogen sulfide	11	0.41
Cooking odor – Chicken breast	Carbon disulfide	283	0.5
Bathroom odor- Urine	Methyl mercaptan	0.07	0.06
	Hydrogen sulfide	32	0.41
Bathroom odor- Feces	Hydrogen sulfide	32	0.41
	Methyl mercaptan	2.3	0.07
	Acetic acid	29.7	6.0

5 In the examples which follow, several color changing indicating agents that are sensitive to very low levels (for example > 0.01 parts per billion (ppb), more preferably from >10 ppb, and most preferably >100 ppb) of amines, ammonia, sulfur compounds, carboxylic acids and aldehydes were identified (Table 3). While the indicating agent may not detect the lower levels of odorous compounds immediately, it may change color in response to these low levels over a period of time, which may be hours (for example, in

the case of a diaper), days, weeks or even months (such as in an air filter). The indicating agents are all available from Aldrich Chemical Co. of Milwaukee, Wisconsin.

Michler's Hydrol reacts with amine or sulfur compounds according to the following reaction:

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20 Although the odor absorbing agents which are specifically mentioned in the  
examples below are nanoparticles from Nissan Chemical America Corporation of Houston,  
Texas and Michler's Hydrol from Aldrich Chemical, other odor absorbing agents such as  
activated charcoal, sodium bicarbonate, clay, zeolites and molecular sieves, which are  
known in the art, and other high surface area materials or nanoparticles may also be used  
25 as the odor absorbing agent.

The nanoparticles used in the practice of this invention can act as carriers for at least one metal ion present on the surface of the nanoparticle, and the metal ion creates an active site that binds with at least one gaseous compound and/or odorous compound thereby removing the compound from the surrounding environment. Nanoparticles can also absorb certain gaseous compounds and/or odorous compounds from the surrounding environment by adsorption directly onto the surface of the nanoparticles.

The nanoparticles are modified with metal ions that ionically bond with compounds such as gases and odorous compounds. "Metal ion" refers to salt ions and/or ion complexes of transition metal elements designated as IB through VIIIB on the periodic table. Other ions can be used in the invention as well. The nanoparticle may be made from any of silica, alumina, magnesium oxide, titanium dioxide, iron oxide, gold, zinc oxide,

copper oxide, and combinations thereof, and may have thereon at least one metal ion of copper ion, silver ion, gold ion, permanganate ion, chlorite ion, persulfate ion, iron ion, and combinations thereof.

Modified nanoparticles are made by mixing nanoparticles with solutions containing metal ions. Such solutions are generally made by dissolving metallic compounds into a solvent, resulting in free metal ions in the solution. The metal ions are drawn to and adsorbed onto the nanoparticles due to the electric potential differences. Further discussion of the modification of nanoparticles may be found in US patent application 10/137052, filed on April 30, 2002, which is incorporated by reference.

It is also possible to bond metal and silica particles to form a "coordinate" and/or "covalent bond." This may have a variety of benefits, such as reducing the likelihood that any of the metal will remain free during use (e.g., after washing). Strong adherence of the metal to the silica particles, further, also optimizes odor adsorption effectiveness.

Numerous techniques may be utilized to form a stronger bond between the transition metal and silica particles. Silica sols, for example, are generally considered stable at a pH of greater than about 7, and particularly between a pH of 9-10. When dissolved in water, salts of transition metals are acidic (e.g., copper chloride has a pH of approximately 4.8). Thus, when such an acidic transition metal salt is mixed with a basic silica sol, the pH is lowered and the metal salt precipitates on the surface of the silica particles. This compromises the stability of the silica particles. Further, at lower pH values, the number of silanol groups present on the surface of the silica particles is reduced. Because the transition metal binds to these silanol groups, the capacity of the particles for the transition metal is lowered at lower pH values.

In order to ameliorate the pH-lowering affect caused by the addition of an acidic transition metal salt (e.g., copper chloride), certain embodiments of the present invention employ selective control over the pH of the silica particles during mixing with the transition metal. The selective control over pH may be accomplished using any of a variety of well-known buffering systems known in the art.

The use of pH control in the modification of silica nanoparticles was demonstrated using a 10 weight percent suspension of SNOWTEX-OXS® nanoparticles from Nissan Chemical, having an unmodified particle size of 4 to 6 nm. The pH of the solution was adjusted to 8.7 and then added to a solution of copper chloride with high mixing shear (about 10,000 rpm). The pH, Zeta potential and particle size were monitored and when a positive Zeta potential was obtained the addition of copper chloride was stopped. The resulting copper modified nanoparticle had a particle size of about 43 nm and a surface area of about 500 square meters per gram.



Other techniques may also be utilized to further enhance the strength of the bonds formed between the transition metal and the silica particles.

Coupling agents in an effective amount may be used to link the transition metal to the silica particle, for example. Such coupling agents may be employed with or without the pH adjustment discussed above. In some cases, an organofunctional silane coupling agent may be used to link the transition metal to the silica particles. Some examples of suitable organofunctional silane coupling agents that may be used include, but are not limited to, vinyltrichlorosilane, vinyltrimethoxysilane, vinyltriethoxysilane, vinylmethyldichlorosilane, vinylmethyldimethoxysilane, vinylmethyldiethoxysilane, 5-hexenyltrimethoxysilane, 3-glycidoxypropyltrimethoxysilane, 3-glycidoxypropyltriethoxysilane, 3-glycidoxypropylmethyldimethoxysilane, 3-glycidoxypropylmethyldiethoxysilane, 3-(meth)acryloxypropyltrimethoxysilane, 3-(meth)acryloxypropyltriethoxysilane, 3-(meth)acryloxypropylmethyldimethoxysilane, 3-(meth)acryloxypropylmethyldiethoxysilane, 4-vinylphenyltrimethoxysilane, 3-(4-vinylphenyl)propyltrimethoxysilane, 4-vinylphenylmethyltrimethoxysilane, 3-aminopropyltrimethoxysilane, 3-aminopropyltriethoxysilane, 3-aminopropylmethyldimethoxysilane, 3-aminopropylmethyldiethoxysilane, 3-(2-aminoethyl)aminopropyltrimethoxysilane, 3-mercaptopropyltrimethoxysilane, 3-mercaptopropyltriethoxysilane, 3-mercaptopropylmethyldimethoxysilane, 3-mercaptopropylmethyldiethoxysilane, and partial hydrolyzates thereof.

Of these coupling agents, organofunctional alkoxysilanes, and particularly aminofunctional alkoxysilanes (e.g., 3-aminopropyltriethoxysilane), are preferred.

Generally speaking, the silane coupling agents may be covalently linked to the silica particles through the silanol groups (Si-OH) present on the surface thereof. Specifically, the silicon atom of the silane coupling agent may form a covalent bond with the oxygen of the silanol group. Once the silane coupling agent is covalently linked to the silica particles, the organofunctional group may form a coordinate bond with the transition metal. Copper, for example, may form a coordinate bond with different amino groups present on aminopropyltriethoxysilane coupling agents.

The quantity of odor absorbing agent used in the odor absorbing article will depend on the nature of the article and amount of odor it is intended to absorb, and will therefore vary from article to article. For example, a disposable diaper which is intended to absorb urine and feces odors may contain a different amount of odor to a sheet intended to absorb pet odor over a longer period of time. By measuring the odor absorption capacity of the sheet or article (mg odor absorbable/gram of sheet) and knowing that the indicating agent reacts with the odor compound (mole of odor compound/mole of indicating agent),

the odor absorption capacities can be matched to tune the indicating agent to the odor absorption of the sheet or article. Thus, without intending to limit the invention in any way, the indicating agent may be present in an amount of from 0.001 to 15% wt/wt, more preferably from 0.005 to 5% wt/wt, and most preferably from 0.1 to 1% wt/wt.

- 5 As the amount of indicating agent used in the invention will depend on the amount of odor which can be absorbed by the article, the concentration of indicating agent which is applied to the article will also vary according to the article.

**Table 3: Visual indicating agents and the specific odors that cause color change**

Visual Indicating Agent	Odor or Odor Class
Michler's Hydrol	Ammonia, amines, sulfur compounds
Copper salts and complexes	Ammonia, amines, sulfur compounds
Rose Bengal (Acid Red 94)	Sulfur compounds
D&C Red 28 (Acid Red 92)	Sulfur compounds
Cobalt salts and complexes	Sulfur compounds, aldehydes, amines
Copper phenanthroline	Sulfur compounds and amines
Iron salts and complexes	Sulfur compounds and amines
Phenol red	Aliphatic carboxylic acids
Cresol red	Aliphatic carboxylic acids
Neutral red	Aliphatic carboxylic acids
3-Nitrophenol	Aliphatic carboxylic acids
Brilliant Yellow	Aliphatic carboxylic acids
Bromothymol blue	Aliphatic carboxylic acids
Chlorophenol red	Aliphatic carboxylic acids
Pararosaniline base	Ammonia and amines
Alpha-naphtholbenzene	Ammonia and amines
Naphthochrome green	Ammonia and amines

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In the examples which follow, a color-changing visual indicating agent was dissolved in a solvent (e.g. water, alcohol or acetonitrile) to give a concentration in the range of from 1 mg/ml to 100 mg/ml. The solution was then applied to a substrate (e.g. cellulose, cotton, nonwoven, glass fiber) by one of the following methods:

- 15 (a) dropping known amounts of the solution onto the surface of the substrate, allowing the liquid to wet the substrate, and then allowing the substrate to air-dry;
- (b) dipping the substrate into the solution, nipping it to remove the excess solution and then air-drying or oven-drying the substrate in a low temperature oven;
- (c) spraying the solution onto the substrate and allowing it to dry; or

(d) printing the solution onto the substrate by flexographic, off-set or inkjet printing.

The substrate was optionally pre-coated with an odor absorbing agent before the visual indicating agent was applied.

5 Samples containing the visual indicating agent were tested by placing the sample into a jar with 2 cm x 2 cm cellulose tissue which had been impregnated with 2 drops of an odor solution (25 mg odor in 25 ml of solution). A lid was placed onto the container and the time and completeness of the color change observed.

### Example 1

10 A dilute solution of isovaleric acid (a major foot odor component) available from Aldrich Chemical was prepared by adding 25 mg of the acid to 50 ml of deionized water and stirring for 30 minutes in a sealed container. This was used as an odor standard to mimic foot odor.

15 An odor absorbing coating was applied onto a Scott® paper towel, available from Scott Paper of Mississauga, ON, Canada via a dip and air-dry method. The odor absorbing agents for this example were alumina-coated silica nanoparticles SNOWTEX-AK®, available from Nissan Chemical.

20 A visual indicating agent, phenol red (also available from Aldrich Chemical) was added in solution (10 mg/ml) by placing 1 to 5 drops of the solution onto the towel and allowing it to air dry.

25 In one embodiment multiple drops were placed in a row and in another embodiment a row of spots containing 1, 2, 3 or 4 drops on the same spot was created to allow a gradient strip to measure the capacity of the treated towel to absorb odor. The coating on the towel absorbs the odor and the visual indicating agent, being sensitive to the odor, reacts with the odor and slowly changes color.

30 The towel was attached inside the top of the container and was prevented from coming into contact with the solution of isovaleric acid. Within 3 minutes the color of the first spot had changed from red to almost yellow, indicating the presence and absorption of acid odor. With time the other spots changed from red to yellow, reflecting the dye concentration in the spot, i.e. the higher the dye concentration the longer the time taken to change color.

35 By following the same procedure cresol red, neutral red, 3-nitrophenol, Brilliant Yellow, bromothymol blue and chlorophenol red (all available from Aldrich Chemical) were also shown to be sensitive to low concentrations (0.01 to 0.0015% wt/wt) of aliphatic acid odors, with a color change becoming visible within 3 to 30 minutes of exposure to the acid odor, the time depending on the concentration of the indicating agent applied to the towels.

The color range was extended by mixing phenol red with a small amount of F,D&C Blue 1 dye (also available from Aldrich Chemical) to convert the initial color to orange/brown. On exposure of the spot to acid odor, the orange/brown color changed to green, indicating the absorption of the acid odor (the phenol red dye is converted to a yellow color by acid odors while the F,D&C Blue 1 dye is not sensitive to acid odors and therefore remains unchanged. The resulting spot is thus a mixture of yellow and blue, which results in a green spot). Thus, it was shown that it is possible to obtain a variety of color changes based on color mixing of primary colors.

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### Example 2

In order to test the ability of Michler's Hydrol to detect thiols, 1 ml of a reaction mixture was placed into each of 6 vials containing 10  $\mu$ l of furfuryl mercaptan (0, 0.228, 0.456, 0.912, 1.824 and 3.648 ppm, respectively), 980  $\mu$ l of buffer containing 40 mM sodium acetate and 4 moles/liter guanidine chloride, pH 5.1 and 10  $\mu$ l of 0.65 mg/ml MH dye (BDMB), all available from Aldrich Chemical Chemical Co.. After incubation of all the vials at room temperature for less than 5 minutes, a portion (200  $\mu$ l) from each vial was transferred to a microtiter plate well, and the absorbance at 590 nm was measured using a microtiter plate reader (Dynex Technologies of Chantilly, Virginia (Model # MRX)). The absorbance can also be measured in the range of 580-615 nm.

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As shown in Figure 1, a standard curve was derived using furfuryl mercaptan as a model thiol odorous compound detectable by the BDMB method. In Figure 1 the x-axis is the concentration of furfuryl mercaptan in ppm from 0 to 4 and the y-axis is the inverse of the absorbance at 590 nm. The sensitivity of thiol detection was found to be very high in this method, and it was even more sensitive than the gas chromatography headspace method described below.

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### Example 3

As garlic has a sulfur compound (diallyl thiosulfinate (allicin)) as its major odorous component, this was used as a practical example to test the reaction of Michler's Hydrol to sulfur odors. Fresh-cut garlic was placed in a jar with a MH-dyed Scott® paper towel and the jar was sealed. The paper towel in the garlic containing jar was observed to change color (from blue to colorless) within 3-5 minutes, whereas no color change was observed in a control jar.

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### Example 4

As shown in Figure 2, a standard curve was derived using ammonium hydroxide solution as an ammonia odor source detected by BDMB (MH-dye). In Figure 2 the x-axis is the concentration of ammonia in ppb from 0 to 400 and the y-axis is the absorbance at 590 nm. Into each of 8 vials, 50  $\mu$ l of a specific concentration of ammonia solution (0, 0.01, 0.02, 0.04, 0.08, 0.16, 0.32, and 0.64%, respectively) was mixed with 150  $\mu$ l of MH solution (20  $\mu$ l of 10.0 mg/ml MH in CH<sub>3</sub>CN with 5.0 ml of 40 mM sodium acetate and 4 M guanidine HCl, pH 5.1), all available from Aldridge Chem. Co. of Milwaukee, Wisconsin and the vials were sealed and incubated for less than 4 min.

The solutions were then transferred to microtiter plate wells and the absorbances were measured at 590 nm using the microtiter plate reader from Dynex Technologies of Chantilly, Virginia (Model # MRX). The absorbance readings were plotted against the concentrations of ammonia solutions, with the concentrations being represented as parts per billion (ppb). The sensitivity of ammonia detection was very high according to the MH-dye method, and it was shown that the sensitivity could be altered by varying the MH-dye concentration.

#### Example 5

A standard curve was also prepared for the detection of urea odors by BDMB (Figure 3) using the same methodology as described above, and BDMB was also found to be sensitive for this odor. In Figure 3 the x-axis is the concentration of urea in moles per liter from 0 to 9 and the y-axis is the absorbance at 590 nm.

#### Example 6

Odor absorption was determined using headspace gas chromatography testing conducted on an Agilent 5890, Series II gas chromatograph with an Agilent 7694 headspace sampler, both available from Agilent Technologies, Waldbronn, Germany. Helium was used as the carrier gas (injection port pressure: 12.7 psig (188.9 kPa); headspace vial pressure: 15.8 psig (210.3 kPa); supply line pressure: 60 psig (515.1 kPa)). A DB-624 column that had a length of 30 m and an internal diameter of 0.25 mm was used for the odorous compound (available from J&W Scientific, Inc. of Folsom, California).

The operating parameters used for the headspace gas chromatography are shown below in Table 4.

**Table 4: Operating Parameters for the Headspace Gas Chromatography Device**

Headspace Parameters		
Zone Temps, °C	Oven	37
	Loop	42
	TR. Line	47
Event Time, minutes	GC Cycle time	10.0
	Vial eq. Time	10.0
	Pressuriz. Time	0.20
	Loop fill time	0.20
	Loop eq. Time	0.15
	Inject time	0.30
Vial Parameters	First vial	1
	Last vial	1
	Shake	[off]

5 The test procedure involved placing 0.005-0.006 g of a sample containing the odor absorbing agent in a 20 cubic centimeter (cc) headspace vial. Using a syringe, an aliquot of the odorous compound was also placed in the vial. The vial was then sealed with a cap and a septum and placed in a headspace gas chromatography oven at 37°C. After ten minutes, a hollow needle was inserted through the septum and into the vial. A 1 cc sample of the headspace (air inside the vial) was then injected into the gas chromatograph.

10 Initially, a control vial with only the aliquot of odorous compound was tested to define 0% odorous compound adsorption. To calculate the amount of headspace odorous compound removed by the sample, the peak area for the odorous compound from the vial with the sample was compared to the peak area from the odorous compound control vial. Testing was done with 5 µl of 2,3-butanedione, 5 µl of acetaldehyde, and 5 µl of 3-methyl  
15 butanal. Each sample was tested in duplicate.

### Example 7

The ability of BDMB to control or absorb sulfur (thiol) odors was determined using ethyl mercaptan (EtSH) from Aldrich Chemical as a specific example of a sulfur odor.

20 A control sample containing 1 ml of the above buffer and water was prepared in a closed vial. A sample containing only 1 ml of buffer was also prepared, as were two samples containing 1 ml of 0.5 mg/ml and 2.0 mg/ml MH, respectively. A sample containing 1 ml of 0.5 mg/ml MH and 5 mM ZnCl<sub>2</sub>, both from Aldrich Chemical, was also

prepared to ascertain the effect of the addition of a metal salt to the MH, and then a final sample containing 5 mM ZnCl<sub>2</sub> only was prepared.

2.0 mg of ethyl mercaptan was injected into each sample and the samples were left to stand at room temperature for about 5 minutes. 1 ml of headspace from each sample was then determined by GC analysis according to the method described above, and the results are shown in Table 5.

**Table 5: Absorption of ethyl mercaptan (EtSH) by MH in the presence and absence of metal salts**

Sample	Volume of head space from 2mg EtSH (ml)	Area of the Peak in GC Analysis (AU)	% Odor Reduction
Control	1.0	1 061 270	-
Buffer alone	1.0	867 528	18.3
MH (0.5mg/ml)	1.0	712 649	32.9
MH (2.0mg/ml)	1.0	667 661	37.1
MH (0.5mg/ml) + ZnCl <sub>2</sub> (5mM)	1.0	638 016	39.9
ZnCl <sub>2</sub> (5mM) alone	1.0	8709 78	17.9

From these results, it is apparent that BDMD is suitable for both absorbing and indicating the presence of a sulfur odor. Furthermore, the results show that the rate of absorption of odorous compounds by BDMD is enhanced when a metal salt is added.

### Example 8

The effect of BDMD on the absorption of urine odors was also determined by comparing the effect of adding BDMD to a sample containing urine with a sample to which no BDMD had been added (Table 6).

A first control sample (control 1) containing 2 ml of urine was prepared in a closed vial, and a second control sample (control 2) containing 2 ml of urine placed on a pad was also placed in a closed vial. Vials containing 1 mg urease and 0.15 mg MH, respectively (all available from Aldrich Chemical), were prepared, and a pad with 2 ml urine (as per control 2) was placed into each of these vials.

The samples were left to stand at room temperature for about 5 minutes. 1 ml of headspace from each sample was then determined by GC analysis according to the method described above.

The results indicate that BDMB is effective to reduce the peak (RT 0.77min) obtained in the GC headspace analysis of urine. Additionally, it was also observed, based on a sniff-test, that BDMB-treated urine has no significant odor.

5 **Table 6: Effect of urease and MH on the GC peaks obtained from the headspace of urine samples**

#	System	Area of the peak at RT 0.77 min	% Change of the peak at RT 0.77 min	Area of the Peak at RT 1.95 min (x10 <sup>6</sup> )
1	Only Urine (2 ml) (Control1)	434015	-	1.228
2	Urine (2 ml) + pad (0.3 g) (Control 2)	705262	-	1.126
3	Control 2 with urease (1 mg)	917030	+30.0	1.162
4	Control 2 with MH (0.15 mg)	299491	-57.5	1.227

#### Example 9

To confirm that BDMB is suitable for use as an indicating agent for sulfur odors, 10 four KIMWIPES® tissues, available from Kimberly-Clark Corporation, Dallas, TX, USA, were dyed with MH (0.5 mg/ml) from Aldrich Chemical. ZnCl<sub>2</sub> (5 mM), also from Aldrich Chemical, was added to two of the KIMWIPES® tissues. Each KIMWIPES® tissue was placed in a closed vial, and ethyl mercaptan (EtSH) odor (also from Aldrich Chemical) was injected into one vial containing a KIMWIPES® tissue with MH only, and into one vial 15 containing a KIMWIPES® tissue with both MH and ZnCl<sub>2</sub>. In both instances, a marked change in color was observed between the vials containing the odor and the vials into which the odor was not injected (not shown).

It was therefore concluded that BDMB is an effective, multi-functional odor reducing agent for sulfur, amine and ammonia odors which are major components of, among others, 20 urine, feces, dog and cooking odors.

#### Example 10

SNOWTEX-C® silica nanoparticles from Nissan Chemical were modified by placing 20 mg copper chloride in 20 ml of a 20% wt/wt SNOWTEX-C® nanoparticle suspension. 25 KIMWIPES® tissues from Kimberly-Clark Corporation were coated with the copper ion modified silica nanoparticle suspension and allowed to air dry. These light green colored KIMWIPES® tissues were placed into a vial and exposed to 10 ppm ethyl mercaptan odor (Aldrich Chemical). The KIMWIPES® tissues immediately turned blue giving a visual



indicator of absorption of odor and that the odor absorbing tissue was working. The experiment was repeated with the copper chloride being in a dry powder form, and the same color change was observed.

5

#### Example 11

A KIMWIPES® tissue was coated with a 1% wt/wt solution of Rose Bengal Dye (Acid Red 94) from Aldrich Chemical and air-dried. This bright red dye was rapidly decolorized when exposed to ethyl mercaptan, also from Aldrich Chemical. Both a water solution and a dried coating of the indicating agent turned colorless when exposed to ethyl mercaptan.

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#### Example 12

D&C Red 28 dye (Acid Red 92), a drug- and cosmetic use-approved dye, was identified as a suitable visual indicating agent and reduced to practice by decolorizing on exposure to sulfur odors. It was demonstrated to work both as a water solution and as a dry coating on a cellulose substrate (1% wt/wt water solution coated onto a SCOTT® paper towel and dried).

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#### Example 13

Cobalt chloride was found to be sensitive to sulfur, aldehyde and amine odors. It changed color from sky blue to colorless in the presence of an amine odor, to brown in the presence of sulfur odors and to green in the presence of aldehyde odors. Cobalt chloride was demonstrated to function both as a water solution and as a dry coating on a cellulose sheet (1% wt/wt water solution coated onto a SCOTT® paper towel).

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#### Example 14

The blue-colored copper phenanthroline complexes turned brown/orange on exposure to sulfur odors and green on exposure to amine odors. This was demonstrated both as water solutions and dry coatings on cellulose substrates (1% wt/wt water solution coated onto a Scott® paper towel).

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#### Example 15

Iron (III) chloride, a yellow/brown solid turned colorless or brown/black when exposed to sulfur or amine odors in a dry powder state. It can be a coating on a substrate

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(1% wt/wt water solution coated onto a Scott® paper towel) or a coating on a silica or alumina powder (Nissan Chemical).

#### Example 16

- 5 In addition to coating the visual indicating agent onto a substrate as described in the previous examples, it was also demonstrated that a solution of the indicating agent can also be printed onto the substrate using an inkjet printer. Inkjet printing deposits a thin coating of indicating agent on top of the substrate, potentially allowing a more sensitive color coating on the substrate.
- 10 Michler's Hydrol from Aldrich Chemical was formulated with inkjet additives shown in Table 7.

**Table 7: Inkjet formulation containing a visual indicating agent (MH)**

INK COMPONENT	VOLUME (ml)
Water (deionized)	0.85
Ethylene glycol	3.0
Glycerol	1.5
Polyethylene glycol (200 MW)	3.0
1,3-Propanediol	1.5
Michler's Hydrol (1.5 mg/ml) in 40 mM sodium acetate and 4 M guanidine HCl, pH 5.1	40.1
TOTAL	50

- 15 The ink solution was loaded into empty Margarita® cartridges (Part #0900400-300) obtained from McDermid-Colorsan of Eden Prairie, Minnesota and printed using a wide format McDermid-Colorsan printer (Model XII). Good inkjet printing on Scott® paper towel substrate was demonstrated. A strip of the printed Scott® paper towel was then exposed to garlic odor and the blue color was observed to decolorize in 10 seconds
- 20 (compared to 3-5 minutes taken to observe the color change of a Scott T® paper towel saturated with MH according to one of the previous examples). Higher sensitivity to the odor was thus observed by inkjet printing the indicating agent onto the substrate.

#### Example 17

- 25 Figures 4(a) and 4(b) show two possible designs for a strip 10 or patch 20 forming the indicator device of the invention, but it will be apparent to any person who is skilled in the art that any other type of design could be used, for example, a floral design, text, a

series of dots, and so forth. The patch 20 and strip 10 of Figures 4(a) and (b), respectively, are divided into four zones 12, 14, 16 and 18 (by way of example only), with the first zone 12 marked "New" containing the lowest concentration of indicating agent and the fourth zone 18 marked "Replace" containing the highest concentration of indicating agent.

By measuring the odor absorption capacity of the sheet or article (mg odor absorbable/gram of sheet) and knowing that the indicating agent reacts with the odor compound (mole of odor compound/mole of indicating agent), the odor absorption capacities can be matched to tune the indicating agent to the odor absorption of the sheet or article.

Thus, if none of the zones have changed color, this indicates that the product has been exposed to less than 25% of its odor absorbing capacity. As the product is exposed to odor, so the zones will begin to change color, with the first zone 12 changing color when 25% of the odor absorbing capacity of the article to which it is attached has been reached, the second zone 14 changing color after 50% of the odor absorbing capacity has been reached, and so on, until the fourth and end zone 18 will change color when 100% of the odor absorbing capacity has been reached.

Figure 5 shows a disposable diaper 50 having an outer cover 60 onto which a visual indicating patch 20, as described above, has been printed.

While the invention has been described in detail with respect to specific embodiments thereof, it will be apparent to those skilled in the art that various alterations, modifications and other changes may be made to the invention without departing from the spirit and scope of the present invention. It is therefore intended that the claims cover or encompass all such modifications, alterations and/or changes.